PATENT ABSTRACTS OF JAPAN

(11)Publication number : 06-347639
(43)Date of publication of application : 22.12.1994

(51)Int.CI. G02B 5/28

(21)Application number : 06-071248
(22)Date of filing : 03.03.1994

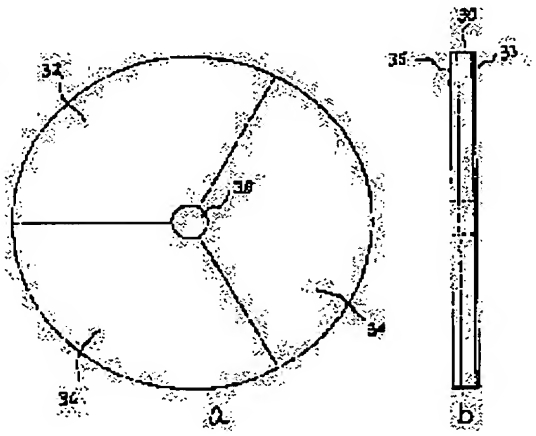
(71)Applicant : TEXAS INSTR INC <TI>
(72)Inventor : ANDERSON CHARLES

(30)Priority

Priority number	Priority date	Priority country
93 25472	03.03.1993	US
93 108095	17.08.1993	US

(54) MONOLITHIC COLOR WHEEL

(57)Abstract:
PURPOSE: To provide a color wheel consisting of two or more interference filters stacked or fixed on a substrate without using a frame or a spoke.
CONSTITUTION: Filters 32, 34, 36 are preferably abutted upon each other and repesentatively formed from many layers consisting of materials having respectively different refractive indexes. Since working over a wide range and balancing are not required and the duration of a monochromatic light period is maximized, the color wheel is optically extremely efficient. Since there is no frame and spoke in the color wheel, the aerodynamic efficiency of the wheel can be improved, workload required for rotation is reduced and air noise also can be reduced.



LEGAL STATUS

[Date of request for examination]	30.01.2001
[Date of sending the examiner's decision of rejection]	04.06.2004
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] The color wheel possessing a disk-like substrate and at least two filters attached in said disk, without using a frame and a spoke including much more optical coating layer at least.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the color wheel of such a system especially about the field of a color vision display system.
[0002]
[Description of the Prior Art] A full color image can be displayed by generating much monochrome displays of a suitable color. This generates three monochrome displays using a filter, and is performed in many cases. In the easiest example, three independent projection system in which each has the light source and the filter of itself is used. It becomes irregular independently and the light ****(ed) from each of these light sources is projected on a common screen. Three coincidence color images are unified in an observer's eyes, and colors other than three foreground colors appear.
[0003] As what is replaced with three sets of juxtaposition projectors, it is serially projected on three monochrome images on a screen at the rate which can unify three continuation images in an observer's eyes. Thereby, a full color image is generated by only the one light source, a modulator, and the **** projector. For realizing such a color system, it is necessary to change a filter to a high speed between the displays of each image. Typically, this lays three filters in a wheel configuration using metalworking or a shaping plastics frame, and is performed. Next, three colors which a color wheel and a call rotate a **** filter wheel ahead [of the source of the white light], and ask for them from the white light are ****(ed).
[0004] The color wheel of the conventional technique holds three filters in an aluminum processing wheel typically, and is created. Since the force arises by rotation of a wheel, the metal hub and rim for keeping a wheel unhurt are needed. Along with the joint between filters, the metal spoke is prolonged from the hub to the rim, and a filter is held in a right location. A metal wheel must be aligned and equilibrated with a precision, and must guarantee smooth actuation of a color wheel.
[0005]
[Problem(s) to be Solved by the Invention] The above mentioned color wheel has some faults according to the structure. Since a system depends [1st] on the ****(ed) light which is always monochrome, the projection system in time amount taken for each spoke to carry out horizontal OFF of the aperture of the projection system must not operate. Therefore, the image to which the effectiveness of a display system may fall becomes dark, so that the width of face of a spoke is wide. Windage resistance arises in the 2nd by the metal spoke to rotate, the turning effort of a wheel is further needed for it, and a noise increases far. Moreover, the cost of a color wheel also tends to become high by the effort for equilibrating a wheel with an assembly precision.
[0006]
[Means for Solving the Problem] A color wheel is formed by attaching an interference filter in a disk according to one example, without using a frame and a spoke. The color wheel indicated can be manufactured cheap and also has the advantage that optical effectiveness is still higher. Furthermore, the color wheel indicated makes rotation easy as much more aerodynamic, and has the advantage that a wind noise is reduced.
[0007]
[Example] There is the approach of using an interference filter as the one **** approach. The interference filter consists of a substrate which the above optical coating deposits further. If the thickness and the ingredient of a layer are selected carefully, transparency and reflection property of a device will turn into frequency dependent extremely. Such a filter is the colour selection beam splitter of non-extinction nature at the essential target

which it is often called [target] a die clo IKKU filter, and penetrates and reflects the light of specific wavelength. A bandpass, a band stop, a long bus, and several sorts of filters including a short pass can be constituted.

[0008] An interference filter operates by [reflected light waves / configuration] generating destructive interference. When light advances the interface between two extinction media, it is reflected by the interface or light penetrates an interface. Reduction of the amount of reflected lights increases the amount of transmitted lights. Since reflection and transparency are dependent on the refractive index of an ingredient, they can select coating from which a refractive index differs, and can change reflection and a transparency property. In the case of vertical incidence, a reflection factor is given by the degree type.

[Equation 1]

$$R=\left[\frac{n_2-n_1}{n_2+n_1}\right]^2$$

ここに、

R =反射率

n_1 =第1媒質の屈折率

n_2 =第2媒質の屈折率

[0009] When three media exist, reflection arises in respect of each field. Drawing 1 shows the reflection at the time of an incident wave 23 advancing from the 1st medium 20 to the 3rd medium 22 through the optical coating 21, and a transmitted wave. On account of explanation, the 1st medium 20 is set to air and n1=1.0, the 2nd medium is set to magnesium fluoride and n2=1.38, and the 3rd medium 22 is set to glass and n3=1.5. Whenever it reflects the reflected light by the interface with a medium with a high refractive index, 180 degrees of phases change. The thickness of coating 21 is equal to one fourth of the wavelength of light, or 180 degrees of phases of reflected waves 25 and 27 shift, and it is made for each other to be offset as the odd times in the case of antireflection coating.

[0010] A more complicated filter uses many coating-material layers in many cases. Typically, since an ingredient with a high refractive index and an ingredient with a low refractive index are the quarter-wave length layers which carry out alternation, it is called a multilayer periodic system in many cases. Drawing 2 shows five-layer coating used as a reflecting mirror. The path of a reflected wave 28 is symbolically shown for the purpose of explanation to drawing 2 . Whenever it reflects by the interface from a layer to a high layer with a low refractive index, a 180-degree phase change arises. It has the phase shift which is odd times all whose reflected waves 28 are 180 degrees, configuration-interference arises, and a big reflected wave is obtained.

[0011] It depends for the response of an interference filter on the frequency and incident angle of incident light. To a given angle of incidence, the thickness of optical coating is only small quarter-wave length to one frequency. Therefore, it interferes in a reflected wave completely only on the frequency. or [that reflection of other frequencies is strengthened] -- or it decreases. Since more complicated optical system is constituted, many filters are made to deposit on a substrate serially, and the spectrum part from which each differs can be ****(ed).

[0012] Optical coating can be performed with some means including vacuum evaporationo and sputtering. In vacuum evaporationo coating, an ingredient sample is heated enough and evaporated. Next, a steam can be condensed on the substrate by which coating is carried out. Contiguity maintenance of the substrate and the target ingredient which should be deposited which was cooled in the case of sputtering is carried out into a plasma chamber. The plasma carries out the impact of the target and the particle of target material is separated. Next, these particles condense on a cooling substrate. The thickness of optical coating is strictly controllable by supervising coating in a deposition process. As an ingredient used for optical coating, it divides and a zirconium dioxide, zinc sulfide, diacid-ized silicon, a titanium dioxide, tungsten titanium, magnesium fluoride, and cerous fluoride are contained.

[0013] According to the 1st example, some filters whose number is three typically accumulate on a glass substrate according to an individual. While depositing each filter, the mask of the remaining substrate is carried out. Although it is sizes [filters / all] typically, it is necessary to make a filter into different size depending on application, or to consider as the mutually proportional size. Since the time amount from which light does not serve as monochrome will be prolonged if a gap and the superposition section are between filters, as for a filter, comparing is desirable. A blanking is needed like the color wheel of the conventional technique during the period of arbitration when the light of two or more colors goes into aperture. Therefore, a blanking is further needed by the gap and the superposition section of a filter, and the optical effectiveness of a display system falls. The color wheel indicated may be much more more nearly aerodynamic than the color wheel of the conventional technique, therefore there is little rotational energy of a wheel, and it ends and there is also little generating of a wind noise. The color wheel indicated cannot be equilibrated and can reduce a manufacture effort and cost remarkably.
[0014] Drawing 3 a shows the monolithic color wheel by the 1st example. Typically, the substrate disk 30 is transparent in some [at least] spectrums which are visible spectrums, and can be used as the ingredient of arbitration which can bear the heat which the light by which a focus is moreover carried out on a color wheel generates. Plastics, such as Xtal, glass, and an acrylic, is contained as an example of such an ingredient. Substrates are optical glass, such as Tempax or 7740Pyrex(es), typically.
[0015] Three sets of color filters 32, 34, and 36 are formed on the substrate disk 30. Typically, each filter is ** size and spreads at 120 degrees on a disk. The filter is compared preferably. constituting a small number of filter more depending on a system, or constituting a filter further -- ****** -- there are also things. In this example, a filter is chosen so that red, green, and the blue three primary colors may be made to penetrate. A filter 32 is a long pass filter and makes a minimum of 80% of the incident light of 50% of the incident light of 600nM, and 620-730nM penetrate less than 1% of the incident light of 370-550nM typically. A filter 34 is a short pass filter and makes a minimum of 80% of the incident light of 50% of the incident light of 505nM, and 390-480nM penetrate less than 1% of the incident light of 540-750nM typically. A filter 34 is a band pass filter and makes a minimum of 80% of the incident light of 505 and 50% of the incident light of 575nM(s), and 540nM(s) penetrate typically less than 1% of the incident light of 380-460nM and 610-730nM. A filter can be chosen so that the light of the outside of a visible spectrum may be made to penetrate, and it can be made into the band stop filter instead of a band pass filter. The filter of arbitration which can bear the heat which can constitute on a substrate and is generated from the light source can be used.
[0016] Drawing 3 b is drawing showing the edge of the monolithic color wheel by the 1st example. As for the color wheel, antireflection coating 33 is typically performed to the opposite side of a color filter 35. Typically, wheels are a diameter of 15.24cm (6 inches), and 3.18mm (1/8 inch) thickness, and have the 19.1mm (3/4 inch) hole for carrying a wheel in the center on a motor shaft.
[0017] In drawing 4 , the color filter wheel by the 1st example is installed in the projection system, and is shown. The focus of the light from the light source 40 is carried out on a color wheel 44 with a lens 42. As for a color wheel 44, it is advantageous to arrange to the focus of a lens 42 and to reduce the illumination area of a color wheel 44. Increase of illumination area increases the rate of time amount that two or more colors are contained in illumination area. Like a period second paddling table of the arbitration in which two or more colors are generated by the color wheel, since a projector cannot operate, the effectiveness of the projection system is restricted by the rate of time amount that two or more colors are contained in illumination area. The fault of arranging a color wheel to a focal plane is that extinction generating heat localizes. Therefore, it becomes far high temperature especially at the time of a halt of a color wheel. In order to attain low-fever stress rather than effectiveness, a color wheel can be detached and arranged from a focus.
[0018] If a color wheel 44 rotates by the motor 46, the light of the color for which it asks will be transmitted to a lens 48. The focus of the light is carried out on the space optical modulator 50 (SLM) with a lens 48. SLM can be used as the device of the arbitration which can modulate light, such as a digital micro mirror device (DMD) and a liquid crystal device (LCD). A transparency liquid crystal device is shown on account of explanation. After becoming irregular, image formation of the light is carried out to the image typically observed on Screen 53 with a lens 52. The signal with which a controller 54 supervises the location of a color wheel, and is sent to SLM is synchronized with a colored light. The location of a wheel can be supervised by pursuing the location of a motor 46 or pursuing the color and mark on a wheel using a sensor 56.

[0019] Although the color wheel to indicate is examined about the color projection system, others have application of such a device in large numbers. For example, as shown in drawing 5 , a wheel can be used for ****(ing) light included in a camera. Thereby, a color camera can be managed now with one imager to all three colors. The focus of the light 58 from a photographic subject is carried out with a lens 60, and it passes the aperture 62 of a camera. The light which passed aperture 62 passes one more lens 64 and the color filter wheel 66. Next, light passes one more lens 68 and illuminates the phot receptor besides a charge-coupled device (CCD) 70 or arbitration. A controller 72 supervises the output of an imager, and the location of a color wheel 66, and the information about a field is acquired. The location of a color wheel can be supervised by supervising the location of a motor 74, using a sensor 75. The mark used for a sensor 75 detecting the color transition at the time of a filter carrying out rotation passage of the sensor, or displaying the point on filters, such as white paint on the color wheel edge between blue and a red filter, is only detected.
[0020] The filter in a precedent can be selected so that only the element of the spectrum with which each has a very narrow pass band may be covered. Although this enables it to identify shading which the color approached [the machine] in the application (machine vision application) to ******, it is useful. For example, if the Orange filter with which some differ is used, a machine can classify Orange according to a color. Another example is helping to select a filter in a far infrared region and to identify a target and a lure with a progressive just far-infrared (FLIR) system.
[0021] As described above, in the another example, a reflective filter is used instead of a transparency filter. A non-transparence substrate becomes usable with a reflective filter. As described above, a reflective filter can be constituted on a wheel-like substrate or the substrate of other configurations. The substrate of another configuration by the 2nd example is shown in drawing 6 . Drawing 6 shows the same polygon mirror 76 as what is used for the scanner of various classes. Each sides 78, 80, and 82 of a polygon mirror 76 can be used as a unique filter.
[0022] The reflective color wheel by the 3rd example used for a DMD display system is shown in drawing 7 . The focus of the light from the light source 84 is carried out on a color wheel, and light is reflected there toward the space optical modulator which is DMD88 here. DMD88 reflects light alternatively and forms the image which projects on direct or a screen and is observed. It guarantees that a controller 90 supervises the position sensor 92 on a motor 94, and a motor continues being synchronized with a space optical modulator. Use of the reflective color wheel which has the reflective space optical modulator of drawing 7 , and the transparency color wheel and space optical modulator of drawing 4 are in agreement. The image which projects on direct or a screen and is observed using the space optical modulator of the wheel of one of classes and one of classes can be formed.
[0023] The 4th example is shown in drawing 8 a and drawing 8 b. This example shows the laminating color wheel which used the separate filters 96 and 98,100 which fixed on the disk 102. Preferably, it is Norland. A filter fixes to the substrate disk 102 using the elevated temperature of NOA-61 grade, and the continuation layer of optical transparence adhesives. Probably a filter can be separately manufactured in the shape of a ** sheet by this example, and a disk can be made to fix. A filter can be manufactured with the ingredient of the optical and the arbitration which fills an environmental demand of a color wheel. Glass, plastics, and Xtal are contained as an example of a suitable ingredient. Since this example has some advantages of frame loess or a spoke loess design and does not need masking during deposition of a filter, it is easy to manufacture. Since a filter is formed on the substrate of itself, a laminating color wheel is thick and is usually typically heavier than the monolithic color wheel by the 1st example.
[0024] Although indicated about the specific example of a monolithic color wheel, the optical projection system, and an optical camera system, unless it is indicated by the claim, the range of this invention is not restricted by such specific example. Furthermore, although this invention has been explained about the specific example, if it is this contractor, it shall be thought that various corrections are obvious and such all corrections shall go into a claim.
[0025] The following terms are further indicated about the above explanation.
(1) Color wheel possessing at least two filters attached in said disk, without consisting of a . disk-like substrate and at least one-layer optical coating layer, and using a frame and a spoke.
[0026] (2) It is a color wheel given in . 1st term, and vacuum deposition of said filter is carried out on said disk.
(3) It is a color wheel given in . 1st term, and said filter is vapor-deposited on a substrate and said substrate

fixes on said disk.
[0027] (4) It is a color wheel given in . 1st term, and said disk is glass.
(5) It is a color wheel given in . 1st term, and said filter is reflexibility.
[0028] (6) It is a color wheel given in . 1st term, and said filter is constituted by the layer of the ingredient with which it is permeability and refractive indexes differ, vacuum deposition of said ingredient is carried out on said disk, and said disk is glass.
[0029] (7) The spoke loess color wheel on the light source which projects light in accordance with . optical path, and said optical path which **** said light, It is the image display system to provide. Said color wheel A disk-like substrate and at least two filters which are constituted by at least one-layer optical coating layer, and are attached on said substrate, Providing, said image display system possesses further the optical modulator between said optical-path absentminded which modulates said light, and said color wheel and the controller which synchronizes actuation of said space optical modulator.
[0030] (8) It is the display of . claim 7 publication, and said space optical modulator is a liquid crystal device.
(9) -- a . disk-like substrate and at least two filters which consist of at least one-layer optical coating layer, and are attached in said substrate -- since -- the camera system possessing the spoke loess color wheel which filters the light from said light source, at least one-layer optical coating layer, the phot receptor lei which detects said ****(ed) light, and said color wheel and the controller which synchronizes said actuation of a phot receptor.
[0031] (10) It is a camera system given in . 9th term, and said phot receptor leis are charge coupled devices.
(11) It is a system the . 7th term or, and given in the 9th term, and the monitor which supervises the location of said color wheel further is provided.
(12) It is a system the . 7th term or, and given in the 9th term, and said filter is permeability.
[0032] (13) It is the polygon mirror with which even . has a reflexibility light filter on the above field, said filter is constituted by at least one-layer optical coating layer, and vacuum deposition of said layer is carried out on said field.
[0033] (14) Color wheel constituted with two or more interference filters which accumulate or fix to a substrate, without using . frame and a spoke. Filters 32, 34, and 36 are preferably created by the layer of a large number from which it is compared with and a refractive index differs typically. Since extensive processing or an extensive balance are not needed but the persistence time of a homogeneous-light period is made into the maximum, the color wheel is very efficient optically. An empty noise also has few workloads which a frame and a spoke want to lose to a color wheel, and rotation takes highly to aerodynamic study-effectiveness few.

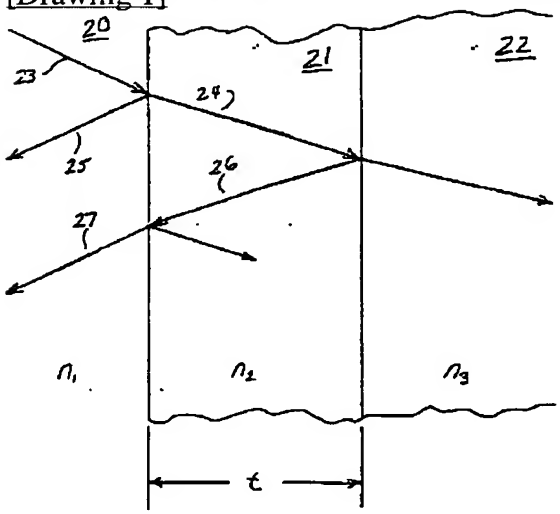
[Translation done.]

* NOTICES *

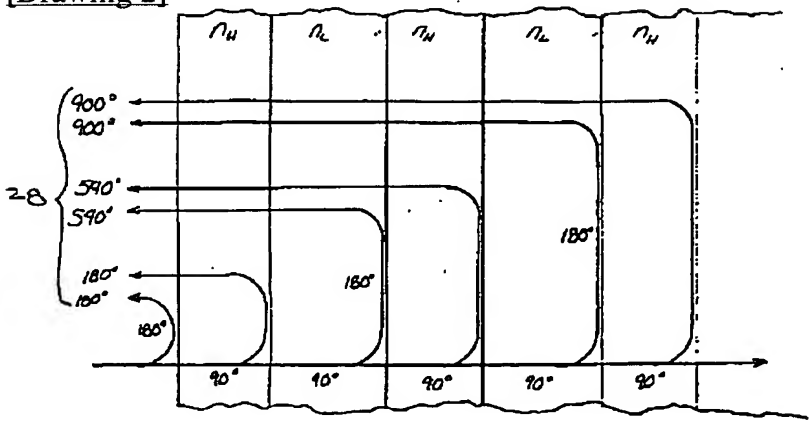
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

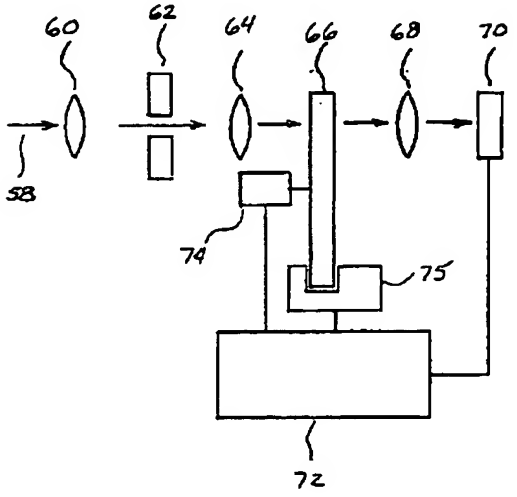
[Drawing 1]



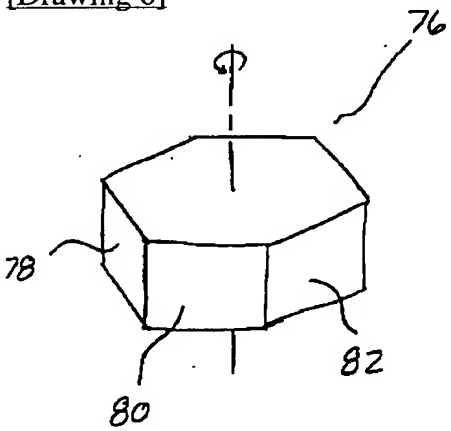
[Drawing 2]



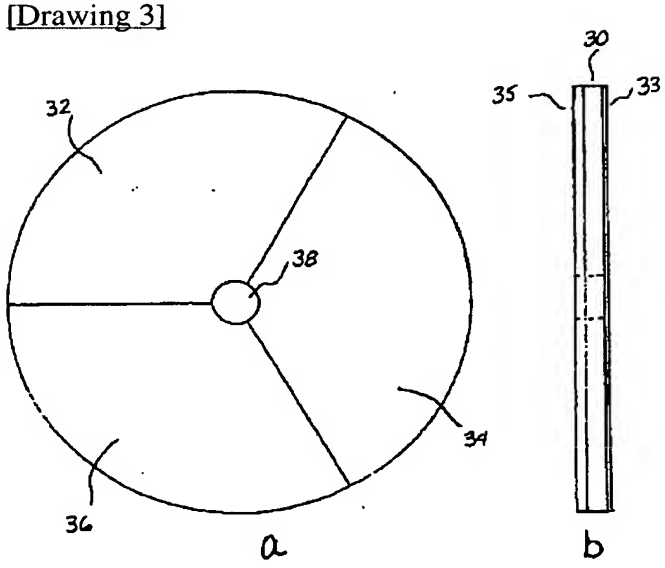
[Drawing 5]



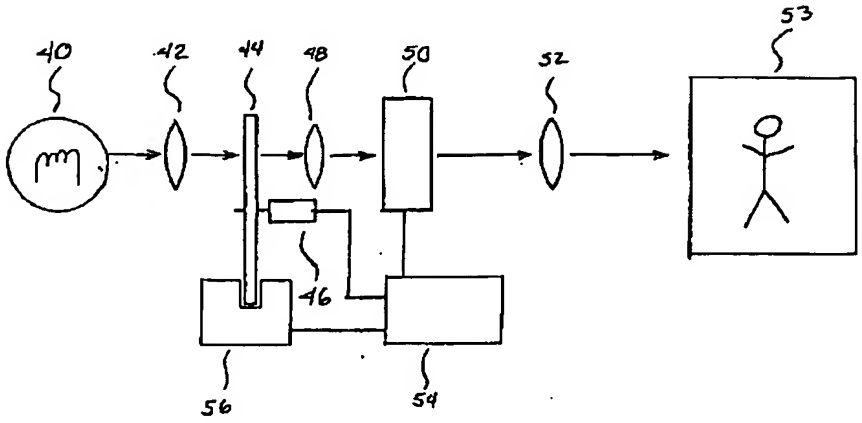
[Drawing 6]



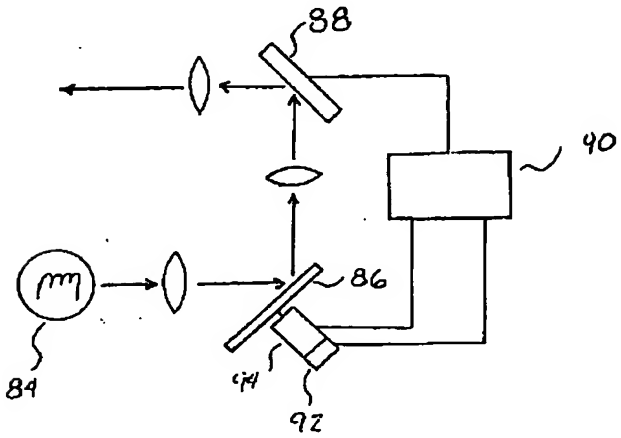
[Drawing 3]



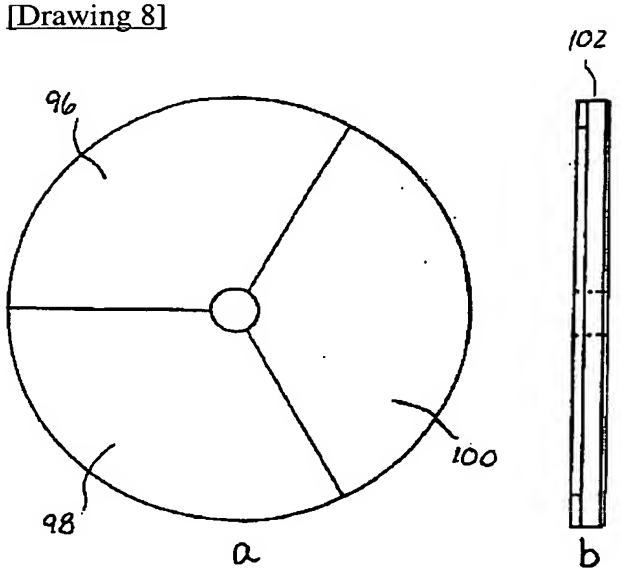
[Drawing 4]



[Drawing 7]



[Drawing 8]



[Translation done.]